SPACE RADIATION EFFECTS LABORATORY

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for the

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

11970 JEFFERSON AVENUE, NEWPORT NEWS, VIRGINIA

THE SPACE RADIATION EFFECTS LABORATORY

ANNUAL REPORT - 1967

ORIGINAL CONTAINS
COLOR ILLUSTRATIONS

operated by

THE COLLEGE OF WILLIAM AND MARY

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

COVER PHOTOGRAPH - THE EXTERNAL 600 MEV PROTON BEAM OF THE SREL CYCLOTRON

The cover photograph was taken on Polariod film with the light generated by the external 600 Mev proton beam ($\approx 2 \times 10^{11}$ protons/sec) as it emerged through a thin window (at the right in the photograph) from the vacuum pipe in the Magnet Hall. The beam then passed towards the left into a linear array of six rectangular pieces of plastic scintillant, each being one foot long, six inches high, and one inch thick in the direction into the plane of the photograph. The bright vertical lines show the interfaces between pieces.

Since the scintillant was only one inch thick, while the beam was of approximately circular cross-section of three inches in diameter, a portion of the beam was scattered out of the scintillant in the first 24 - 30 inches of its path. This caused the gradual decrease in brightness from right to left. The range of the protons in scintillant is about 56 inches, and is clearly visible in the fifth slab from the right. A portion of the beam which initially passes on either side of the array apparently enters the scintillant at an intermediate point and thus continues through the last slab without having exhausted its energy, causing the faint luminosity visible to the left of the range point.

The color of the photograph is a characteristic of the particular scintillant used, and is not of the same origin as the bluish Cerenkov light associated with swimming pool reactors.

CONTENTS

I. INTRODUCTION.................................. 3

II. ORGANIZATION OF THE LABORATORY................. 5

III. ACCELERATOR OPERATION AND DEVELOPMENT.......... 8

A. Synchrocyclotron

B. Electron Accelerators

IV. SPECIAL SERVICES.............................. 13

a. Computer Services

b. Health Physics

V. EXPERIMENTS IN PROGRESS....................... 16

VI. PUBLICATIONS.................................. 19

I INTRODUCTION

This report gives account of the first full year of accelerator operation of the Laboratory. During this year the major accelerator, the synchrocyclotron, passed from a stage of testing and beam studies into full use by experimenters. Indeed, demand for time on the cyclotron was heavy enough to cause the initiation of weekend running early in the year, increasing available time by more than 35% over the previous five-day schedule. The cyclotron generally runs well, and adherence to the schedule has been reasonably close. For example, the machine was operated continuously for an 800-hour period starting on November 14, with only a four-hour loss of available time due to a minor fault.

The electron Linac has been operational as far as the accelerator proper is concerned for a good part of the year. For many applications of the Linac the electron beam transport system into the Combined Target Area (CTA) is required, and by December the alignment, shielding and testing of this system had been completed and beam had been efficiently transported into the CTA. Regularly scheduled operation of the Linac is now underway.

The Dynamitron operated at reduced beam current and 2 Mev for some weeks during November and December. Maintenance of this machine is still troublesome, and extensive work is being planned to improve reliability.

The on-line computer system of the Laboratory is being used with its first experiments. It should prove a powerful weapon in view of the increasing complexity of experiments.

Having summarized the physical state of the Laboratory, it is appropriate to devote some attention to its organization and mode of operation. On September 1, the responsibility for administration of the Laboratory was assumed by the College of William and Mary as a direct contractual obligation to the NASA. This change carried with it a commitment by the College to continue to provide access to the Laboratory not only to NASA-sponsored experiments but also to experiments by all those scientists whose proposed experiments are of high scientific merit and are compatible with the facilities and time available.

On November 1, the staff of the Laboratory was reorganized into a structure which is described in a later section (II) of this Report.

A handbook, entitled the SREL Users Handbook, containing information on the accelerators, beams, computer, operational rules, etc. for the Laboratory, has been in preparation. The first portions have been sent to experimenters and interested persons, and further portions will become available during the forthcoming year.

As can be seen from the list of experiments in progress during 1967 (Section V), there is a wide variety of work programmed for the SREL accelerators. Concentrating attention on the institutional cyclotron experiments, more than fifteen experiments are on the docket, a large number for a full schedule, and extraordinary for a half-schedule. Even with the expectation that parallel running apparatus and procedures will develop rapidly at SREL, the heavy demand for cyclotron time will severely limit the time available to each experiment, unless two or three experiments can run simultaneously on the same beam.

The Laboratory is now entering a crucial period. The first experimental results have been published, but the success of the various programs now in progress is vital to the future of the SREL program. It will be only a few years until other accelerators with much greater intensity and superior beam quality will be completed. During the next two years the production of quality science at SREL must be sufficient to provide justification for a cyclotron improvement program which will keep this machine competitive.

Robert T. Siegel

ROBERT T. SIEGEL
Director

II ORGANIZATION

1. On November 1, 1967, the Laboratory was reorganized into the structure outlined below and in Figure 1:

   a. Cyclotron Division

      This Division is responsible for maintenance and operation of the 600 Mev synchrocyclotron and support of experimenters using this machine. It is also responsible for study of the machine and such modification as will improve performance and reliability. It is composed of the Operation and Maintenance Section and the Experimental Support Section.

   b. Electron Accelerator Division

      This Division is responsible for the maintenance, operation, and development of the 3 Mev high-current Dynamitron and the 10 Mev Electron Linear Accelerator.

   c. Technical Services Division

      This Division provides various technical services for the entire Laboratory, and is composed of the following Sections:

      1. Electrical Engineering Section

         This Section is responsible for the maintenance and operation of the electrical power distribution system in the Laboratory. It is also responsible for the power sections of systems involving large electrical currents such as beam transport magnets.

      2. Electronics Engineering Section

         This Section is responsible for the maintenance of electronic components in the Laboratory, and construction of specialized electronic systems which will improve performance of the accelerators and provide improvement of service to experimenters.

      3. Mechanical Engineering Section

         This Section is responsible for mechanical components of the accelerators, including the vacuum and cooling systems, etc. It provides drafting and machine shop services for the entire Laboratory.

d. Special Services Division

This Division is composed of two Sections, as follows:

1. Computer Section

This Section is responsible for providing general computing and on-line data acquisition services via the IBM 360/44 system.

2. Health Physics Section

This Section is responsible for recommending a program of radiation safety procedures in the Laboratory and on the site, and for administering the Radiation Safety program of the Laboratory. It carries on such health physics measurements as will provide basis for the safety program.

e. Administrative Services Division

This Division performs the functions of providing property administration, clerical and communication services, building maintenance, etc.

2. Authorized personnel strength of the Laboratory is presently a total of sixty-three, consisting of eleven professional, thirty-eight technicians, six administrative, and eight security and custodial employees. The professional employees have been compensated since November 1 under a plan which places these employees on a scale comparable to William and Mary faculty members insofar as salary is concerned. Other employees are compensated on a plan which was established in accord with the specialized nature of the various Laboratory functions.

3. The supervisory staff of the Laboratory as of December 31, 1967, follows:

Siegel, R. T. - Director
Funsten, H. O. - Assistant Director
Welsh, R. E. - Assistant Director

Bish, R. E. - Electronics Engineering Section
Burtner, G. E. - Cyclotron Operations Section
Haskins, J. W. - Electrical Engineering Section
Hendrick, W. G. - Health Physics Section
Holman, H. K. - Administrative Supervisor
Hopp, D. I. - Computer Services Section
Sowers, H. L. - Electron Accelerator Division
Stearns, C. S. - Mechanical Engineering Section

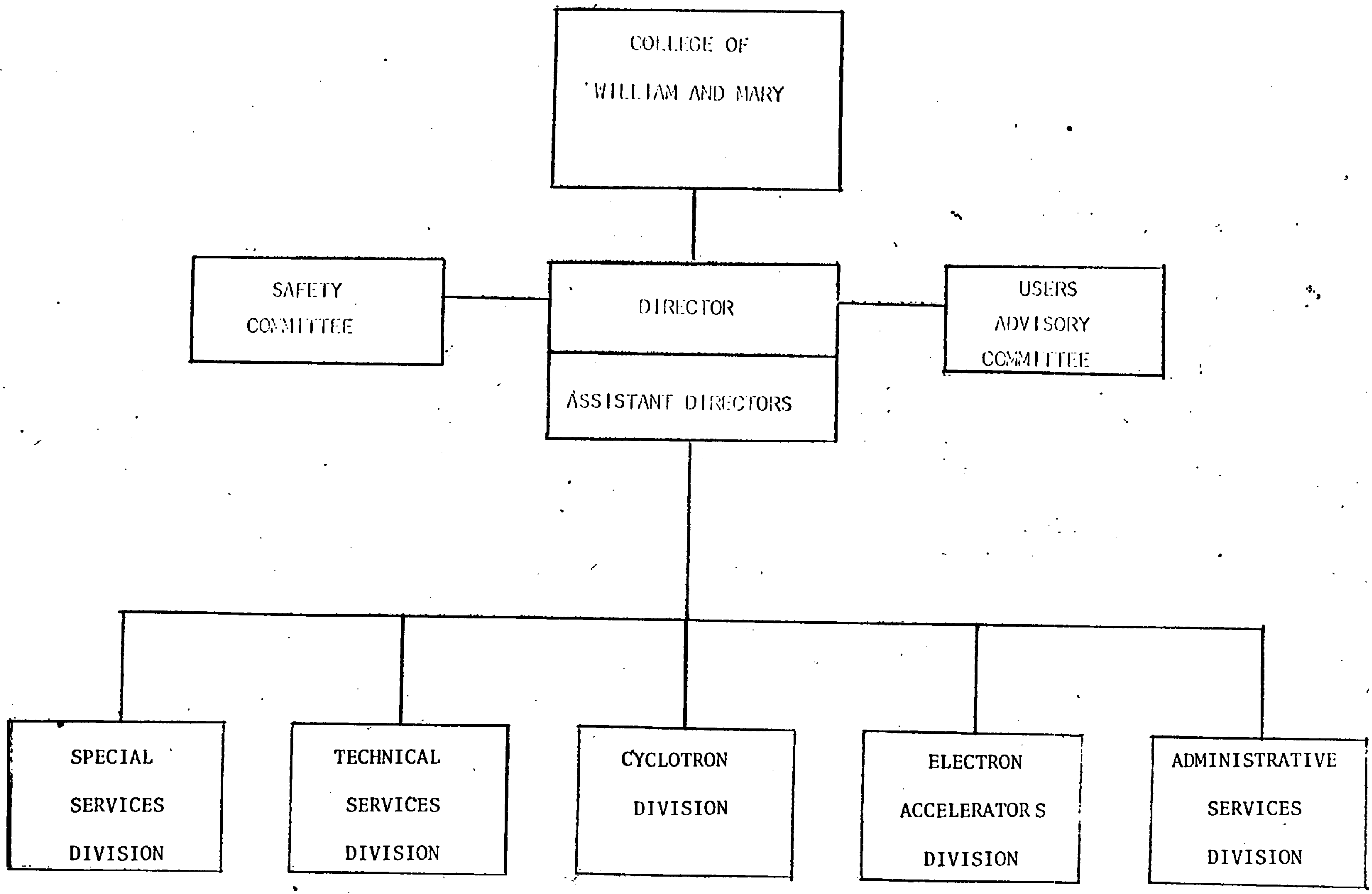
COLLEGE OF
WILLIAM AND MARY
SAFETY
COMMITTEE
DIRECTOR
ASSISTANT DIRECTORS
USERS
ADVISORY
COMMITTEE
SPECIAL
SERVICES
DIVISION
TECHNICAL
SERVICES
DIVISION
CYCLOTRON
DIVISION
ELECTRON
ACCELERATORS
DIVISION
ADMINISTRATIVE
SERVICES
DIVISION

FIGURE 1

III ACCELERATOR OPERATION AND DEVELOPMENT

A. Synchrocyclotron

1. The cyclotron operated on a five-day week until the last week in March, when weekend operation was initiated with support from the Commonwealth of Virginia. Since the fixed expenses of Laboratory operation are borne by the basic contract with NASA, a modest contribution thus made possible a 35% increase in available machine time. The weekend time is scheduled on the same basis as weekdays in that a 50-50 division between NASA-supported and institutional experiments is strived for.

2. From June 5 - 11 the cyclotron was shut down for installing the mechanical structure for the slow extraction cee system. After fitting in place the structure was removed until the electrical tests are completed.

   The testing of the entire cee system is now being done through a mock-up of the environment in which the cee will be finally located. The driver and final stage have undergone full power check out with a prototype coaxial transmission line. Peak-to-peak voltage of 6.5 KV was obtained before insulators failed. (Design goal is 8 - 10 KV.) Improved insulator design and changes in the transmission line have been executed, along with better screen bypassing and insulation of the final stage of amplification.

   A prototype of the programming circuits for the cee system has been constructed and tested. Modular construction of these circuits in the final version will facilitate maintenance, and the driver stage will also be modified to permit its location outside of the shielding wall. Duplicate circuits will be prepared wherever practicable, and extended testing of the final system will be performed before installation in 1968.

3. The summary of time distribution for the calendar year 1967 follows in Table 1 and Figure 2.

TABLE 1 - TIME SUMMARY, 1967

a.	Total Scheduled Time in Hours		8760
b.	Holidays and Unavailable Weekends		704
c.	Maintenance		464
d.	Cooldown		219
e.	Installation and Testing		136
f.	Net Scheduled Available Time [a - (b + c + d + e)]		7238
g.	Unscheduled Downtime		224
h.	Available Time (f - g)		7014
i.	"Operational Efficiency" = h/f		96.9%
j.	Division of Available Time		
	NASA-sponsored Experiments	3148	
	Institutional Experiments	3866	7014
k.	Parasite Time		
	NASA-sponsored Experiments	104	
	Institutional Experiments	192	296

The fraction of machine time scheduled for NASA-sponsored experiments was greater than 50% in the latter half of the year, and the 1967 total is close to the anticipated 50%.

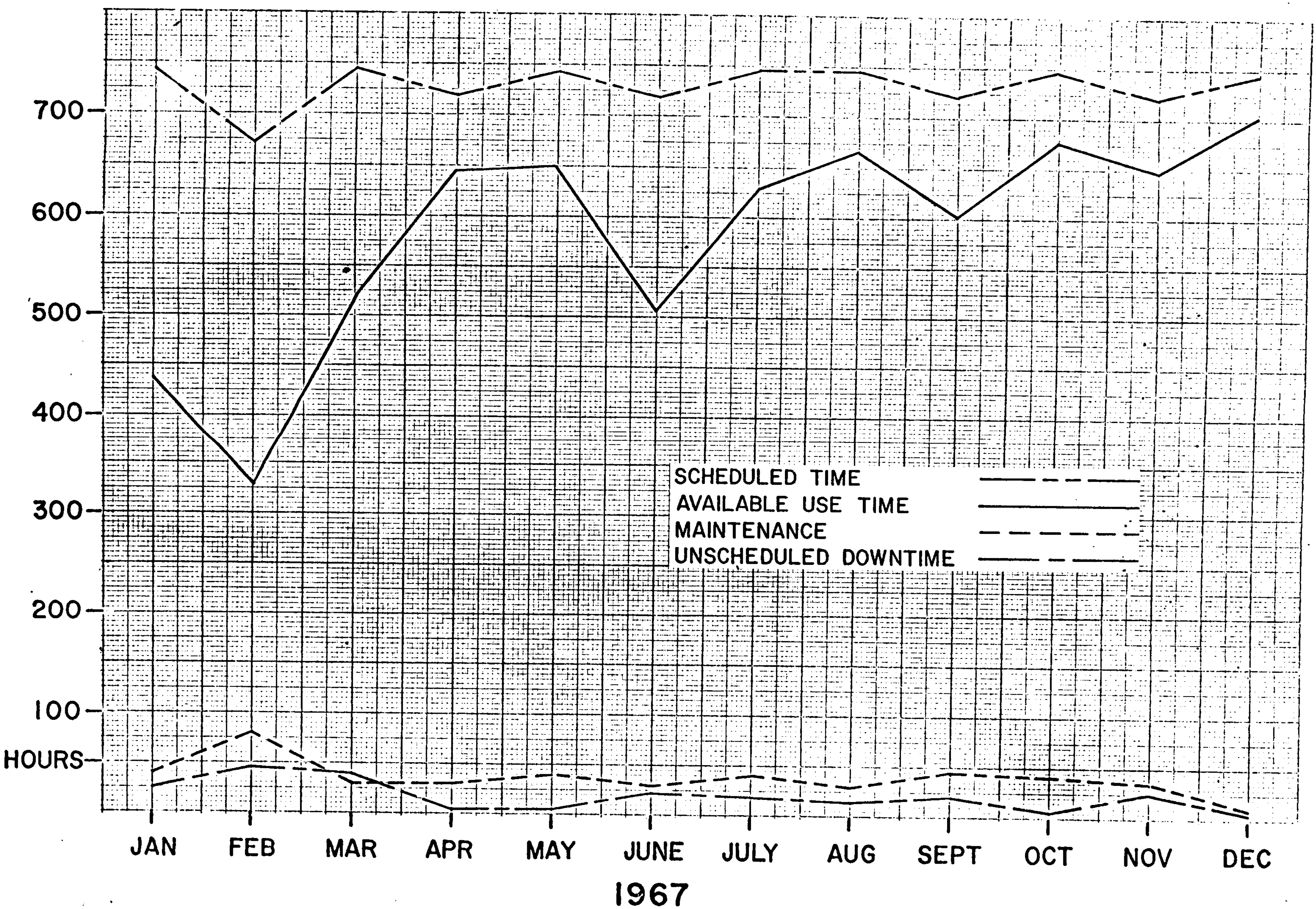

FIGURE 2 – CYCLOTRON TIME SUMMARY

4. A new ion source pulser was designed and built by the Cyclotron Operations Section. The pulser was placed in service on November 13, and has proved satisfactory for approximately 1500 hours of operation.

5. Improved lighting installations were installed for the South face of the cyclotron vault. This facilitates work during platter changes and at the meson window of the machine.

6. Thermocouple targets were installed on each platter in order to provide standardized measurement of internal proton beam. Calibration of these targets against a similar target brought from CERN by E. G. Michaelis shows that the SREL internal beam normally is 50 - 65% that of the CERN machine. The lower figure is obtained after platter changes, while improvement of the vacuum and RF systems results in a higher beam current after sustained operation. The permanently installed thermocouples are inserted at eight-hour intervals to provide a record of machine operation, and may be inserted at user request to check stability.

7. A study of methods for measuring the absolute internal circulating beam of the cyclotron was made by E. G. Michaelis, Visiting Professor of Physics at William and Mary. The use of a rectangular blade as a thermocouple target of theoretically simple properties enabled the internal current of the SREL machine to be established as 0.85 μa under normal running conditions. The work is summarized in SREL Internal Report SC-2.

8. A survey of methods used in measuring the external 600 Mev proton beam was executed by L. W. Swenson and W. G. Hendrick. The results, given in SREL Internal Report SC-1, indicate a flux of 2×10^{11} protons/sec at full beam.

9. The meson channel quadrupole magnets have begun to arrive and the completed channel is scheduled to be installed by September 1, 1968. The channel will lead to a substantial increase in intensity of both pions and muons to the Neutron-Meson Area. The project has involved important contributions by D. D. Smith and R. S. Sommers of the Langley Research Center.

10. The arrangement of beam ports through the Neutron-Meson shield wall is being studied with a view to providing a greater variety of pion momenta through a new array of beam ports. It is planned to orient the ports so as to permit simultaneous cooperation of two pion beams along with an extracted 600 Mev proton beam of $\approx 2 \times 10^7$ protons/sec in either of the two proton target rooms. The layout required is described in SREL Internal Report SC-3 by H. O. Funsten and E. G. Michaelis.

11. The modifications to the Proton Target Area to provide a "beam dump" were design engineered in cooperation with Langley Research Center, and necessary magnets ordered. The completion of the beam dump project is anticipated for the latter part of 1968.

B. Electron Accelerators

1. In April a project was initiated to transport the Linac beam to the Combined Target Area (CTA). The major problem was to reduce the stray magnetic field of the cyclotron over the entire length ($\approx$ 85 feet) of the electron beam transport system (EBTS). Extensive shielding with mu-metal cylindrical wrapping has reduced the average field within the vacuum pipe from 2-3 guass to 80 milligauss. The linac beam has subsequently been transported into the CTA over a range of energies from 3.1 Mev (.1% transmission) to 10 Mev (28% transmission), with only slight sensitivity to the cyclotron field. Important contributions to this project were made by M. Phenneger of William and Mary.

2. A project was undertaken to develop electron beam steering and position monitoring instrumentation for the EBTS. This project is nearly completed, and will result in the installation of beam control instrumentation during the forthcoming year.

3. A substantial rearrangement of Dynamitron ancillary equipment (water and electrical control lines) has resulted in improved accessibility of the machine and more area for experimentation.

4. The Dynamitron has undergone continual modification, and now operates with fairly good reliability at 2 Mev and 100 μa. During December 102 hours of operation was achieved under these conditions, with 58 hours of unscheduled downtime. A new beam tube and further changes directed towards 3 Mev operation at design beam ($\geq$ 5 ma) are planned for the forthcoming year.

IV SPECIAL SERVICES

a. Computer Services

1. The 360/44 computer arrived on May 26 and was officially accepted in July. The acceptance test lasted 30 days and the computer performed most reliably throughout it.

2. The interface, components and programming system arrived in the latter part of September. The entire system was put on-line in time for an experiment that started October 11. The hardware ran continuously and without fault for 100 hours. The system has accumulated several hundred hours of use without significant mechanical or electronic faults.

3. Programming system bugs were discovered during this run, and modifications were made accordingly. Close contact is maintained with the Yale/IBM group, and they and the SREL programming group work together to fix and improve the system. (The Yale Nuclear Structure Laboratory has the only other IBM 360/44 computer designed for on-line data acquisition at an accelerator installation.)

4. It is felt that user-education is of the greatest importance, and four lectures on the programming system were given; a total of about 40 physicists from NASA and the participating institutions attended. A detailed description of the system was written and distributed, and has been included in the Users Handbook.

5. The core memory of the computer was doubled, and the SREL configuration is now almost identical to that at Yale, thus insuring that full advantage can be taken of the Yale/IBM joint study.

6. The SREL computer group is working on improvements to the programming system to make it more useable to those users who rely on different techniques than those common in the Yale low-energy laboratory. Continued emphasis will be placed on making the entire system as convenient as possible for SREL's transient users. The interface components have already been modified to place all signal and event inputs on the front panel.

b. Health Physics

1. A summary of the film badge exposure records for those Laboratory personnel who spend the greatest amounts of time in radiation-controlled areas is presented in Figure 3. No person exceeded the tolerance levels of total-body dose of 1.25 rem per quarter, or approached 5 rem for the year. No major contamination problems or serious unusual occurrences were reported. The greatest single period of exposure to personnel occurred during the work on the slow-extraction

cee in June, 1967.

2. The training of technicians from other groups within the Laboratory in the techniques of Health Physics continued. A six-hour course in Health Physics was presented to thirty-one radiation workers from Langley Research Center.

3. A calibration program has been set up for on-site calibration of both portable and fixed monitoring equipment. Permanent record is maintained of all instrument calibrations performed at the Laboratory.

4. Two remote detectors in the cyclotron vault were relocated to provide more sensitive indication of radiation levels. A surplus hand and foot monitor has been rebuilt and will shortly be put into regular use near the cyclotron vault entrance. Work is also in progress on an air monitor.

5. The installation of additional shielding over the electron accelerator vaults has substantially reduced the high radiation levels which formerly existed over these areas.

6. A study of the radiation levels in the present Neutron-Meson Area experimental cave indicated that the entry of personnel into this cave could be safely effected during cyclotron operation so long as the internal beam stop was inserted into the circulating beam. The result of this investigation is described in the SREL Internal Report HP-1.

AVERAGE EXPOSURE PER MAN

BY DEPARTMENTS YEAR OF 1967

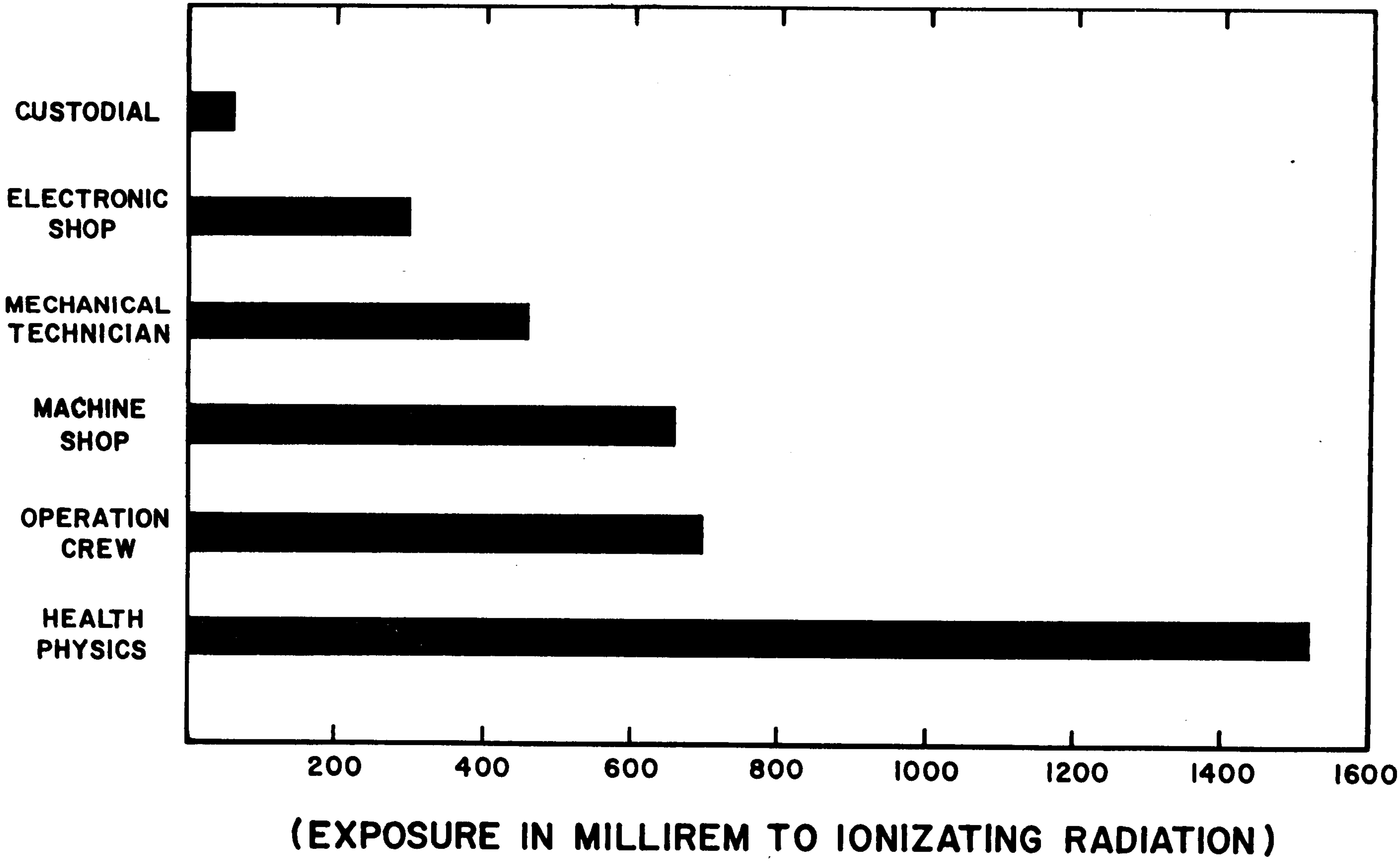

FIGURE 3

V EXPERIMENTS IN PROGRESS - 1967

Following is a list of experiments (with their code designations) which were scheduled for the various accelerators at SREL during the latter part of 1967. The order used in listing experiments is of purely historical origin.

1. CYCLOTRON - INSTITUTIONAL EXPERIMENTS

IC-101. Nuclear Chemistry Studies of (p,2n), (p,pn) and (p,2p) Reactions. R. L. KIEFER; *College of William and Mary*

IC-102. Gamma-Rays from $(p,p'\gamma)$ Reactions. H. O. FUNSTEN, D. HOLT, and B. LIEB; *College of William and Mary*

IC-103. Neutrons from Radioactive Pion Capture. B. MACDONALD, K. GOTOW, W. C. LAM, and P. TROWER; *Virginia Polytechnic Institute*

IC-104. π^- Mesic X-Rays. D. JENKINS, K. GOTOW, J. BOND, and T. WITTEN; *Virginia Polytechnic Institute*

IC-105. Single Nucleons from Pion Absorption. T. WITTEN, K. GOTOW, and D. JENKINS; *Virginia Polytechnic Institute*

IC-106. Three-Photon Decay of the Neutral Pion. J. CARROLL and P. MARTIN; *College of William and Mary*

IC-107. Two-Body Breakup of Be^9 Following π^- Capture. R. C. MINEHART, K. ZIOCK, and W. GRUBB; *University of Virginia*

IC-108. Search for Neutron-Rich Nuclei in Two-Body Final States Following Pion Capture in B^{11}. K. ZIOCK and R. MINEHART; *University of Virginia*

IC-109. Low Energy Charged Particles Ejected from Nuclei by 600 Mev Protons. R. D. EDGE, C. W. DARDEN, and F. R. AVIGNONE; *University of South Carolina*

IC-110. (p,2p) on He^4 and C^{12}. C. F. PERDRISAT, L. W. SWENSON, and R. A. CROCKER; *College of William and Mary*: E. BOSCHITZ, W. ROBERTS, and J. VINCENT; *NASA, Lewis Research Center, Cleveland*: P. C. GUGELOT; *University of Virginia*

IC-111. Proton Irradiation of Rabbit Eye Lenses. W. T. HAM, JR., W. GEERAETS, H. MUELLER, R. C. WILLIAMS, S. F. CLEARY, R. K. HALE, and V. JONES; *Medical College of Virginia*

IC-112. Pionic and Muonic X-Rays. R. E. WELSH, M. ECKHAUSE, R. HARRIS, G. MILLER, W. SAPP, D. EISENHUT, and W. B. SHULER; *College of William and Mary*

IC-113. Pionic and Muonic X-Rays in Liquid Helium. R. WETMORE and J. KANE; *College of William and Mary*

IC-114. Negative Muon Depolarization in Light Nuclei. D. BUCKLE and J. KANE; *College of William and Mary*

IC-115. ($\Pi,\Pi'\gamma$) Reactions in Complex Nuclei - Π-γ Angular Correlation. H. O. FUNSTEN and B. LIEB; *College of William and Mary*

IC-116. Whole Body Irradiation of Mice for LD_{50} and Metabolic Alterations. E. E. STICKLEY, S. W. LIPPINCOTT, J. MONTOUR, and C. ROGERS; *Medical College of Virginia*

IC-117. Measurement of Times of Flight of Neutrons Following Muon Capture in Complex Nuclei. M. PLETT and S. SOBOTTKA; *University of Virginia*

IC-118. Neutron Energy and Angle Distributions in (Π^-,2n) Reactions in Complex Nuclei. D. CHESHIRE and S. SOBOTTKA; *University of Virginia*

IC-119. Neutron Energy and Angle Distributions in Pion Radiative Capture. M. HOLLAND and S. SOBOTTKA; *University of Virginia*

2. CYCLOTRON - NASA-SPONSORED EXPERIMENTS

NC-101. Studies of the Biological Effects of Changed Particle Radiation - Threshold Doses for Hematological Changes. J. E. TRAYNOR, A. M. SIEGAL, L. WINANS, R. SWANSON, A. HERNANDEZ-DIAZ, J. C. MITCHELL, K. HARDY, E. R. BALLINGER, and D. STURROCK; *USAF School of Aerospace Medicine, Texas*

NC-102. Calibration of 300 Mev Proton Spectrometer to be Used Aboard Rockets During Solar Proton Events. L. R. MEGILL; *E.S.S.A., Colorado*

NC-103. Calibration of Charged Particle Detectors to be Flown Aboard Orbiting Spacecraft. G. A. PAULIKAS; *Space Physics Laboratory, Aerospace Corporation, California*

NC-104. Measurement of the Mass and Energy of Secondary Particles Produced in the Interaction of 600 Mev Protons with Complex Nuclei. H. D. ORR; *NASA, Langley Research Center*

NC-105. A Measurement of the Efficiency and Operation Characteristics of Cerenkov Radiators for Use in High Energy Cosmic Ray Experiments. R. J. KURZ, B. J. TEEGARDEN, and L. STONEBREAKER; *NASA, Goddard Space Flight Center, Maryland*

NC-106. Measurement of the Differential Cross Section for Proton Elastic Scattering from He^4. E. BOSCHITZ; *NASA, Lewis Research Center*: P. C. GUGELOT; *University of Virginia*: C. F. PERDRISAT and L. W. SWENSON; *College of William and Mary*

NC-107. A Measurement of the Induced Gamma Activity Produced by Proton Bombardment of Rock and Basalt Material. J. E. CLINE, R. L. HEALTH, E. B. NIESCHMIDT, and C. T. HOWARD; *Idaho Nuclear Corporation, Idaho*

NC-108. A Precise Study of the Characteristics of the Extracted Proton Beam. R. J. KURZ, B. J. TEEGARDEN, and L. STONEBREAKER; *NASA, Goddard Space Flight Center, Maryland*

NC-109. Calibration of a Detector Array for Space Experiments - The Detector, a dE/dx vs E Proton Detector, Has Been Used in Five Satellite Experiments. B. TEEGARDEN, R. J. KURZ, and L. STONEBREAKER; *NASA, Goddard Space Flight Center, Maryland*

NC-110. Precision Measurements of the Proton Beam Profile of the SREL Cyclotron. W. HONAKER and G. HILL; *NASA, Langley Research Center*

NC-111. Precise (P,n) Cross Section Measurements in Aluminum. J. SINGH; *NASA, Langley Research Center*

3. ELECTRON ACCELERATORS

NL-101. Linac Beam Energy and Quality Studies. W. C. HONAKER; *NASA, Langley Research Center*

NL-102. Thick Target Bremsstrahlung. C. A. POWELL, JR.; *NASA, Langley Research Center*

NL-103. Combined Proton-Electron Irradiation Studies. W. C. HULTEN; *NASA, Langley Research Center*

IL-101. Electrodisintegration of Light Elements. R. G. WINTER and M. PHENNEGER; *College of William and Mary*

IL-102. Photofission Angular Distributions near Threshold. J. R. HUIZENGA; *University of Rochester*

ND-101. Radiation Damage Studies of Strain Gauges. C. GROSS; *NASA, Langley Research Center*

ND-102. Radiation Damage to Silicon-Germanium Alloys. C. GROSS; *NASA, Langley Research Center*

VI PUBLICATIONS

Following is a list of (A) articles in scientific journals, (B) papers presented at scientific meetings, and (C) reports, all related to experimental research conducted at the Laboratory. Within each of the three groups the publications are listed in chronological order of appearance.

A. Articles in Scientific Journals

1. 500-VOLT RESOLUTION WITH AN SI(LI) DETECTOR USING A COOLED FET PREAMPLIFIER. R. J. Harris, Jr., and W. B. Shuler; *College of William and Mary*. Nuclear Instruments and Methods 51, 341 (1967)

2. DIRECT OBSERVATION OF HYPERFINE STRUCTURE IN PI-MESIC X-RAYS. R. A. Carrigan, Jr.,; *Carnegie-Mellon University:* W. W. Sapp, W. B. Shuler, R. T. Siegel, and R. E. Welsh; *College of William and Mary*. Physics Letter 25 B, 193, (1967)

3. PIONIC AND MUONIC X-RAYS IN LIQUID HELIUM. R. J. Wetmore, D. C. Buckle, J. R. Kane, and R. T. Siegel; *College of William and Mary*. Physical Review Letters 18, 1003 (1967)

4. A RANGE CHAMBER FOR ELECTRONIC READOUT. A. Coulson, W. Grubb, R. Minehart, and K. Ziock; *University of Virginia*. Submitted to Nuclear Instruments and Methods.

B. Papers Presented at Scientific Meetings

Presented at the Meeting of the Division of Nuclear Physics of the American Physical Society, Madison, Wisconsin, October 23 - 25, 1967.

1. PROMPT GAMMA RAYS FROM 300-MEV PROTON BOMBARDMENT OF LOW A NUCLEI. H. O. Funsten and M. D. Holt; *College of William and Mary*. [Bulletin of the American Physical Society II, 12, 1176 (1967)]

2. ENERGY SPECTRUM OF CHARGED PARTICLES EMITTED FOLLOWING MUON CAPTURE IN SI^{28}. S. E. Sobottka and E. Wills; *University of Virginia*. [Bulletin of the American Physical Society II, 12, 1178 (1967)]

Presented at the Meeting of the Southeastern Section of the American Physical Society, November 3, 1967.

3. LOW ENERGY PARTICLES EJECTED BY 600 MEV PROTONS FROM NUCLEI. R. D. Edge, C. W. Darden, W. F. Lankford; *University of South Carolina*: and H. D. Orr; *NASA, Langley Research Center*

Presented at the 1967 Winter Meeting of the American Physical Society, New York City, November 16 - 18, 1967.

4. OBSERVATION OF PIONIC AND MUONIC X-RAYS IN LIQUID HELIUM. R. J. Wetmore, D. C. Buckle, J. R. Kane, and R. T. Siegel; *College of William and Mary.* [Bulletin of the American Physical Society II, 12, 1049 (1967)]

5. DEPOLARIZATION OF THE NEGATIVE MUON IN LOW-Z ELEMENTS AND HYDROGEN COMPOUNDS. D. C. Buckle, J. R. Kane, R. T. Siegel, and R. J. Wetmore; *College of William and Mary.* [Bulletin of the American Physical Society II, 12, 1050 (1967)]

6. MEASUREMENTS OF 2P-1S NATURAL LINEWIDTHS IN LOW-Z PI-MESIC ATOMS. R. J. Harris, Jr., M. Eckhause, W. B. Shuler, R. T. Siegel, and R. E. Welsh; *College of William and Mary.* [Bulletin of the American Physical Society II, 12, 1050 (1967)]

7. INVESTIGATIONS OF PIONIC AND MUONIC K_α X-RAY TRANSITION ENERGIES IN LOW-Z ATOMS. W. B. Shuler, M. Eckhause, R. J. Harris, Jr., R. T. Siegel, and R. E. Welsh; *College of William and Mary.* [Bulletin of the American Physical Society II, 12, 1050 (1967)]

8. ELECTRIC QUADRUPOLE SPLITTING IN PIONIC ATOMS. R. E. Welsh, W. W. Sapp, W. B. Shuler, and R. T. Siegel; *College of and Mary*: R. A. Carrigan, Jr.,; *Carnegie-Mellon University.* [Bulletin of the American Physical Society II, 12, 1050 (1967)]

Presented at the Annual Meeting of the Radiological Society of North America, Chicago, Illinois, November 26 - December 1, 1967.

9. INFLUENCE OF RADIATION QUALITY ON HOST CAPABILITY FOR TUMOR SUPPORT OR REJECTION. C. C. Rogers, E. E. Stickley, C. D. Moseley, and D. M. Rollins; *Medical College of Virginia*

10. PROTON BEAM UNIFORMITY MEASUREMENTS AT SREL. G. F. Hill, W. C. Honaker, and K. H. Kim; *NASA, Langley Research Center*

Presented at the Annual Meeting of the American Association of Physicists in Medicine, Chicago, Illinois, November 30 - December 2, 1967.

11. SOME CHARACTERISTICS OF LARGE AREA PROTON BEAMS FOR RADIO-BIOLOGICAL RESEARCH FROM THE NASA-LANGLEY CYCLOTRON. K. R. Blake and J. B. Nelson; *Texas Nuclear Corporation*: J. C. Mitchell and S. J. Allen; *USAF School of Aerospace Medicine*

12. PROTON DEPTH DOSE DOSIMETRY WITH THERMOLUMINESCENT DOSIMETERS. K. A. Hardy, S. J. Allen, and J. C. Mitchell; *USAF School of Aerospace Medicine*

C. Reports

The following list includes relevant internal reports of the organizations using SREL facilities. It does not include progress reports on grants or contracts, or preprints of papers which have since appeared in print elsewhere.

SREL Internal Reports

1. EXTERNAL BEAM CURRENT MEASUREMENTS ON THE SYNCHROCYCLOTRON. L. W. Swenson and W. H. Hendrick. SC-1 (1967)

2. MEASUREMENT OF THE INTERNAL BEAM OF THE SREL 600 MEV SYNCHROCYCLOTRON. E. G. Michaelis. SC-2 (1967)

3. PROPOSAL FOR FUTURE MESON BEAMS AT THE SREL SYNCHROCYCLOTRON. E. G. Michaelis and H. O. Funsten. SC-3 (1967)

4. INTERLOCKING OF PHASE III GATE INTERLOCK AND FLIP TARGET-6. W. G. Hendrick. HP-1 (1967)

Langley Research Center Reports

1. GAMMA RADIATION BACKGROUND MEASUREMENTS AT SREL. E. Rind and J. J. Singh. LWP-302 (1966)

2. MONITORING THE SPATIAL INTENSITY OF CHARGED PARTICLE BEAMS USING AN X-Y SCANNING SYSTEM. G. F. Hill, W. C. Honaker, and R. W. Loop. LWP-418 (1967)

3. RANGE ENERGY SPECTROMETER MEASUREMENTS OF THE PROTON BEAMS AT SREL. G. F. Hill, W. C. Honaker, and M. C. McGee. LWP-427 (1967)

William and Mary Reports

1. A GAMMA-RAY SPECTROMETER USING A GE(LI) DETECTOR AND A COOLED FET PREAMPLIFIER. R. J. Harris, Jr. WM-8 (1967)

2. COMPARISON OF INTERNAL BEAMS OF THE SREL AND CERN 600 MEV SYNCHROCYCLOTRONS. E. G. Michaelis and R. T. Siegel. D. Jenkins (*Virginia Polytechnic Institute*). WHEN-11 (1967)